ULTRASONIC SPRAY APPARATUS

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Fig. 1

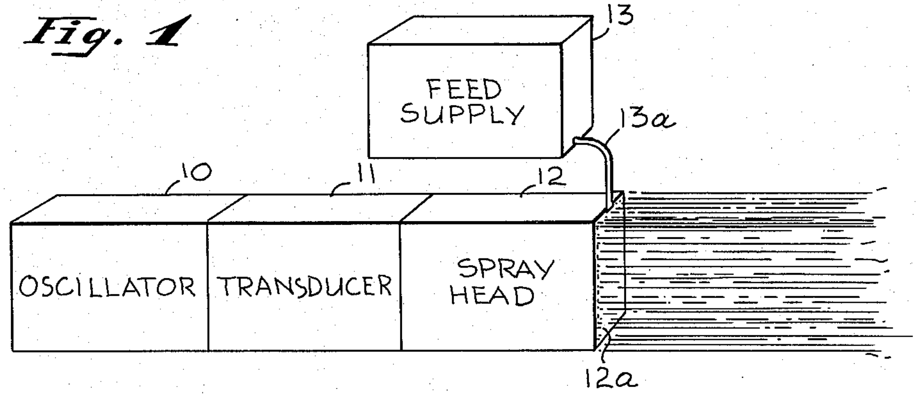
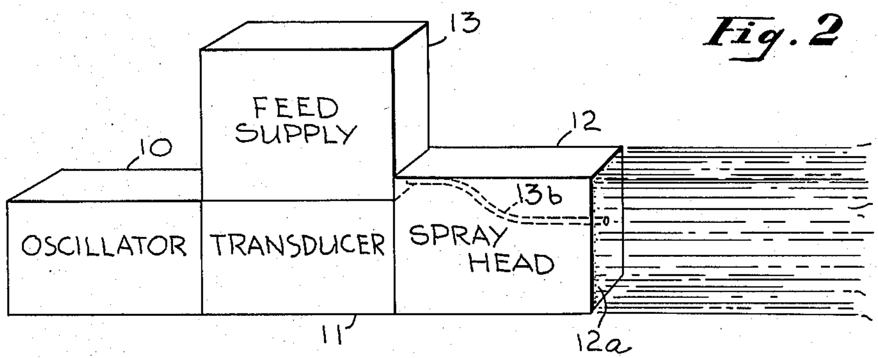


Fig. 2



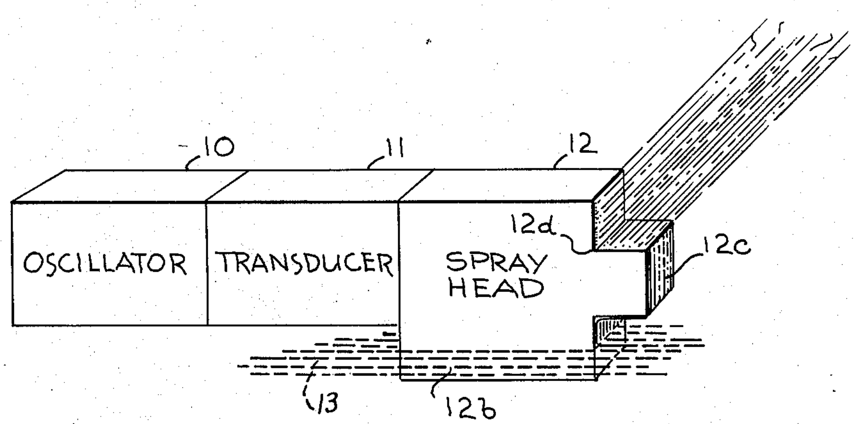


Fig. 3

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ULTRASONIC SPRAY APPARATUS

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The present invention relates to spray devices in general and more particularly relates to a spray device in which ultrasonic energy is used to produce the desired spray.

This application is a continuation-in-part of the original application filed August 19, 1963, and given Serial No. 302,947, now abandoned.

As is well known, spray devices of various designs are extensively used in a number of different fields. Thus, for example, spray mechanisms are used in the field of fuel utilization to atomize the fuels injected into burners for combustion purposes. By "atomization" is meant the breaking down of a substance into fine or minute particles by destroying the molecular cohesion between them. Among the spray devices used today in the field of fuel utilization, atomization of the fuel is primarily obtained by the application of pressure which forces the fuel material, such as a liquid fuel or a powdered solid fuel, through a small or constricting orifice.

Spray devices are also used in the medical field where they are called "vaporizers." In this application, the medicinal liquid is heated until the liquid vaporizes, the vapor pressure that is thusly built up thereafter forcing the vapor through an orifice and toward the patient. Vaporization differs from atomization in that vaporization involves the transfer of heat to a substance, whereas atomization involves instead the transfer of kinetic energy. It will be noted that vaporizers also use the pressure principle mentioned above in that the vapor spray is obtained only in response to the internal build-up of vapor pressure.

Again, by way of example, spray devices are used for the purpose of spraying paints, for spraying chemicals in the photographic field, for forming or depositing thin films of a substance on a surface, as is done in the electronics field, and a host of other uses too numerous to completely delineate here. However, here again, in the main, pressure is the means by which the spray is produced, whether it be air pressure or pressure obtained by some other means.

Thus, as may be expected, one of the important disadvantages of present-day spray devices is that their flow rates are subject to pressure variations. In other words, as will be recognized by those skilled in the art, fluctuations in the pressure used to produce the spray will, in turn, produce corresponding fluctuations in the rate at which the spray material flows out of the orifice, thereby producing non-uniformity in the results sought to be obtained. A further disadvantage lies in the fact that pressure-operated spray devices are not easily controlled when they are started and stopped, that is to say, the flow does not start or stop instantaneously but, rather, takes an undesirable amount of time to increase or decrease which it does exponentially.

A further and fundamental disadvantage of conventional spray devices is that the orifice is a functional part of the system and, therefore, determines the parameters of the spray. Hence, since the orifice is subject to clogging, enlargement with use, and other imperfections, the spray oftentimes leaves much to be desired, especially where very fine work is involved. In this regard, it should also be mentioned that because the orifice itself plays such an important role, careful attention must be paid during the manufacturing process to insure that it will have the proper size and configuration.

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Aside from the fact that conventional spray devices, including vaporizers, have certain disadvantages in common, some of which have been mentioned above, vaporizers suffer from the further singular disadvantage of requiring heat to be applied to them. This is a disadvantage because it limits the usefulness of the device in a number of ways. Thus, it takes what may be a considerable period of time for the pressure that produces the spray to build up. In addition, there are medicinal substances that would decompose or otherwise deteriorate as a result of the application of heat to them. Finally, the continued application of heat raises the environmental temperature to the point where it may be uncomfortable for a patient, especially in a confined space.

Finally, where air pressure is employed, the air oftentimes mixes with the substance being sprayed, which is an undesirable effect because of possible oxidation, dilution of vacuum environment, and the like.

The present invention substantially overcomes the above and still other disadvantages encountered among the prior-art spray devices, and it does so by using ultrasonic power to form the spray rather than pressure. More particularly, in accordance with the basic concept of the present invention, the desired spray is formed by bringing a substance into contact with a spray head that is made to vibrate or oscillate at an ultrasonic frequency. By so doing, a relatively large amount of kinetic energy is almost instantaneously transferred to the substance which, in response thereto, becames atomized, that is to say, breaks down into fine or minute particles. By suitable design of the spray head, the desired spray pattern may thereby be obtained. It should be mentioned that the atomization of a solid, fluid or gas, when an ultrasonic impingement of sufficient force to disrupt molecular cohesion of the material is instituted, has come to be known as the "Snaper Effect," as may be seen from the Directory of Electronic Terms for Space Age Language on page 27 of the July 6, 1963 issue of Electronic Products magazine.

A distinct advantage of the present invention over existing spray devices is that it doesn't require an orifice to achieve atomization, and if an orifice is included, it is used only as a convenient means for delivering the substance to be atomized to the atomizing surface of the spray head. In other words, an orifice is not an essential or functional part of any system embodying the present invention and, therefore, the problems introduced by orifices in present-day spray devices, namely, the previously mentioned clogging, enlargement, etc., are hereby avoided. Furthermore, even where an orifice is used, the inherent nature of the present invention is such that the orifice tends to be self-cleaning or non-clogging due to what may be termed an ultrasonic cleansing action.

A most significant additional advantage of the present invention lies in the fact that, for all practical purposes, a full spray pattern is obtained instantaneously. Stated differently, there is no gradual build-up or decay of the spray with the present invention but, rather, the build-up and decay may be said to be instantaneous. Related to this is the fact that there are no pressure variations to contend with, which means that a constant spray pattern can be obtained over a period of time with the aid of the present invention. These factors are obviously beneficial in that they permit more reliable and much finer work to be done and, in the medical field in particular, they permit the application of medicines without delay and at full strength. Considering the medical field still further, the present invention also opens up new vistas in that medicinal sprays can now be produced with substances that could not heretofore be used because of the deleterious effects of heat. Furthermore, the avoidance of heat and pressure by the present invention now makes it possible to treat areas of the human body not heretofore accessible with conventional devices, such as the sinuses.

As a further indication of the many benefits derived from the present invention, it should additionally be mentioned that far finer and much more uniformly-sized particles may be obtained from an ultrasonic spray device than that which can be obtained with conventional devices.

The novel features which are believed to be characteristic of the invention, both as to its organization and method of operation, together with further objects and advantages thereof, will be better understood from the following description considered in connection with the accompanying drawing in which an embodiment of the invention is illustrated by way of example. It is to be expressly understood, however, that the drawing is for the purpose of illustration and description only, and is not intended as a definition of the limits of the invention.

FIGURE 1 illustrates the basic construction of an ultrasonic spray device in accordance with the present invention;

FIGURE 2 illustrates the FIG. 1 apparatus as it is modified to include an orifice by means of which the substance to be atomized is fed to the spray head; and

FIGURE 3 illustrates a further modification of the FIG. 1 apparatus by means of which a "pumping action" is produced that feeds the substance to be atomized to the spray head.

For a consideration of the invention in detail, reference is now made to the figures in the drawing wherein like or similar parts or elements are given like or similar designations. In FIG. 1, a spray device according to the present invention is shown to basically include an oscillator **10** that can provide a signal at a frequency that is either in the upper audio or in the ultrasonic ranges. Oscillator **10** is coupled to a transducer mechanism **11** whose function it is to convert the electrical oscillations applied to it by the oscillator to corresponding mechanical vibrations or oscillations, and for this purpose the transducer mechanism may include magnetostrictive or piezoelectric apparatus, both of which are presently existing and available. Ferrite is an example of a magnetostrictive material, whereas barium titrate or lead zirconate are examples of piezoelectric materials.

Mounted to or bonded to transducer **11** so as to be an integral part thereof is a spray-head element **12** which, in general, may be made of any material that will freely transmit acoustical waves. More specifically, element **12** is preferably made of a metal or ceramic material. In addition to the fact that element **12** may be made from any one of many different available materials, it can also be given almost any design configuration. However, whatever the design of the spray head, it should be such that a good acoustical match be provided between it and transducer **11** so that the spray-head surface, that is to say, the surface off which the spray or atomization occurs, is an anti-nodal point or point whereat maximum vibrational displacement occurs. Finally, in order to supply the substance to be atomized to the atomizing surface of the spray head, the arrangement in FIG. 1 is also shown to include a feed supply **13** from which there extends a hose, tube or pipe **13***a* through which the substance is fed to the abovesaid atomizing surface.

In its operation, oscillator **10** generates electrical oscillations at a frequency that may be either in the upper audio or in the ultrasonic ranges, preferably the latter. These electrical oscillations are applied to transducer **11** which, as its name implies, converts these electrical oscillations to corresponding mechanical oscillations or vibrations. These ultrasonic vibrations are then transmitted or imparted to spray-head element **12** which, as was previously mentioned, is designed so that its atomizing surface is located at the anti-nodal plane, that is to say, the plane or surface whereat maximum vibrational displacement occurs. In FIG. 1 the atomizing surface is designated **12***a*, and the substance to be atomized is fed to it at a controlled rate by feed supply **13** and connecting tube **13***a*. This substance, which may be either a liquid or a finely powdered material, absorbs the kinetic energy involved and, as a result thereof, the molecular cohesive forces are overcome to the point where extremely fine particles of the substance are produced and sprayed outwardly, the pattern of the emerging spray being determined by the design of the spray-head element, specifically the design of atomizing surface **12***a*. Thus, physical variations of the anti-nodal plane will produce corresponding variations in the spray pattern as well as in spray coverage.

In FIG. 1, spray-head element **12** is shown to be solid and the substance to be atomized fed by external means **13***a* to atomizing surface **12***a*. However, tube **13***a* may be eliminated by modifying the spray head to include a tubular orifice through it, as is shown in FIG. 2, wherein this tubular orifice is designated **13***b*. Thus, in the FIG. 2 arrangement, the substance to be atomized flows from feed supply **13** through internal passageway **13***b* to atomizing surface **12***a* whereat the substance is atomized and sprayed forward according to the design of the atomizing surface, as heretofore explained.

As is shown in FIG. 3, a spray head can be designed by means of which a substance can be supplied to the atomizing surface in what may be termed a "pumping" or "self-feeding" action, thereby eliminating the need both for external tubing **13***a* or internal tubing **13***b*. Thus, in FIG. 3, a spray-head element **12** includes a lip member **12***b* that is integral with and that extends downwardly from the spray-head element. Stated differently, lip member **12***b* is a downward extension of the spray-head element and, in the present instant, is disposed along substantially the full length of the element. Lip member **12***b* extends downward into the liquid substance to be atomized, designated **13**, which would ordinarily be contained in a vessel or reservoir that is open at the top. Although the liquid is shown in the figure, the reservoir is not since, first, it is a very commonplace item, such as a five-sided box-type container, and, second, it is not considered to be a part of this invention. Suffice it to say, therefore, that the vessel containing liquid **13** is open at the top and the member **12***b* is partially submerged in it in the manner illustrated in FIG. 3. Finally, and most importantly, atomizing surface **12***a* also includes a discontinuity, in this case a snub-nosed member **12***c*, that projects from it in a forwardly direction.

In its operation, the ultrasonic vibrations of the spray-head element, in particular the vibrations of lip member **12***b*, force the liquid **13** up and around snub-nosed member **12***c* until it reaches the area of the anti-nodal point, designated **12***d*, whereat the liquid is atomized and sprayed forward in a pattern that is determined by the surface configuration of the anti-nodal point area which, in turn, is determined by the configuration of the discontinuity **12***c*. By way of explanation, this "pumping" or "self-feeding" action occurs because, first, the mechanical vibrations of lip member **12***b* exert a "push" on the liquid and, second, a vacuum layer appears to surround both the atomizing surface and the lip member that exerts a "pull" on the liquid. Consequently, the liquid is both pushed and pulled with the resultant effect that it is pumped or forced up and around the member **12***c* to point **12***d*, as previously mentioned. The pumping action itself can be varied, controlled or enhanced by designing the configuration of the spray-head surface to produce the desired effect. For example, a convex, concave, triangular, round or embossed surface structure may be used instead of the snub-nosed or box-shaped configuration of FIG. 3. Likewise, it should be mentioned that not only does the viscosity of the substance being atomized determine the size of the spray particles, but also the frequency of the vibrations and the delivered power. Hence, by varying either the frequency or the power, or both, particle size may be varied over a range of sizes.

It must be mentioned again by way of emphasis that the FIG. 3 embodiment does not require any, nor does it include any, external or internal tubing of any sort and, in fact, has no orifices, holes, or liquid-containing passages associated with it at all. Rather, the entire spray-head element is solid and the liquid material is fed to its atomizing face solely by the above-described pumping action of what has been referred to as the lip member.

Although a number of particular arrangements of the invention have been illustrated and described above by way of example, it is not intended that the invention be limited thereto. Accordingly, the invention should be considered to include any and all modifications, alterations or equivalent arrangements falling within the scope of the annexed claims.

Having thus described the invention, what is claimed is:

1. Fluid-spray apparatus comprising: an oscillator for generating electrical oscillations at a selected ultrasonic frequency; a transducer mechanism coupled to said oscillator for converting said electrical oscillations to corresponding mechanical vibrations; a spray-head element bonded to said transducer mechanism so that the vibrations thereof are transmitted thereto, said element including an atomizing surface that is defined by two planes meeting at an angle, said atomizing surface having a discontinuity thereon for spraying the fluid in a pattern that is determined by the configuration of said discontinuity, said discontinuity extending forwardly of one of the planes of the atomizing surface and including the other of the planes of said atomizing surface; a reservoir of a fluid substance to be atomized and sprayed positioned beneath said spray-head element; and a member that is integral with said spray-head element and subject to the vibrations thereof, said member extending downward from said element and into said fluid substance, said member being operable in response to the vibrations thereof to

feed said fluid upwardly to the discontinuity, then forwardly and upwardly to the atomizing plane forming one surface of said discontinuity.

2. Fluid-spray apparatus comprising: an oscillator for selectively generating electrical oscillations in the upper audio and ultrasonic frequency ranges; a transducer mechanism coupled to said oscillator for converting said electrical oscillations to corresponding mechanical vibrations; a reservoir of a fluid substance to be atomized and sprayed positioned below the spray apparatus and spaced therefrom; and a solid spray-head element bonded to said transducer mechanism at one end and at the opposite end having an atomizing surface that is defined by two planes at an angle, said element including a discontinuity on its atomizing surface that extends forwardly of one of the planes of the atomizing surface and includes the other of the planes of said atomizing surface, said element also including a member that is integral with and extends downwardly into said reservoir from said spray-head element between the bonding and atomizing surfaces thereof, said spray-head element and the member thereon being operable in response to the vibrations of said transducer mechanism to feed said fluid upwardly to the discontinuity, then forwardly and upwardly to the atomizing plane forming one surface of said discontinuity.

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